This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

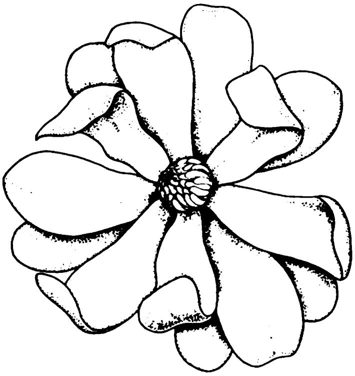
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

LIBRARY
OF THE
ARNOLD ARBORETUM
JAMAICA PLAIN



HARVARD UNIVERSITY

HERBARIUM COPY

FROM THE TRANSACTIONS OF THE ROYAL SOCIETY OF CANADA
SECOND SERIES—1896-97
VOLUME II SECTION IV
GEOLOGICAL AND BIOLOGICAL SCIENCES.

THE GENERIC CHARACTERS
OF THE NORTH AMERICAN
TAXACEÆ AND CONIFERÆ

By D. P. PENHALLOW

MH
2
P5?
LIBRARY OF THE GRAY HERBARIUM
HARVARD UNIVERSITY.
THE GIFT OF
D. P. Penhallow.

FOR SALE BY
JOHN DURIE & SON, OTTAWA; THE COPP-CLARK CO., TORONTO
BERNARD QUARITCH, LONDON, ENGLAND

1896

IV.—*The Generic Characters of the North American Taxaceæ and Coniferæ.*

By D. P. PENHALLOW.

(Read May 20, 1896.)

In 1894 a preliminary paper on the "Classification of the North American Coniferæ," based upon the anatomical characters of the wood, was presented to this society, but reserved for future publication. During the intervening two years extended opportunities for verification and comparison have been offered, and much labour has been expended in the revision of details and the elimination of possible sources of error. In the present paper it is designed to give an account of those characters upon which a differentiation of genera may be based, reserving a discussion of the specific characters for a future occasion.

The present classification had its origin in 1880, and is, so far as I am aware, the first attempt of the kind as applied to the North American woods.

The need of such a work was apparent, not only in the demands arising from an extensive and varied economic application of numerous kinds of woods, but in the requirements of the palæobotanist, who sought for some more exact means of defining species and of establishing the relations of fossil woods to those of recent origin, than are to be found in a merely general knowledge of structure. When it is recalled that fossil woods are commonly represented by the more durable parts of the fibro-vascular structure only—a structure from which many of the anatomical details may have been eliminated by the operation of decay or the subsequent alterations attendant upon petrifaction, in consequence of which it becomes of the highest importance that the taxonomic value of such characters as are yet recognizable should be capable of exact estimation; and that wood applied to economic purposes often requires to be recognized under conditions which render the ordinary means of distinction worthless, it is clear that any system of classification which will admit of a precise limitation of genera and species under all conditions, must possess a high degree of value.

With respect to the application of such a classification to existing species, the view was held, upon general grounds, that if species ould be defined at all, it would be possible to recognize them under ll conditions of growth and economic application. How far this view nay prove to be correct will be demonstrated by the present treatse. With respect to fossil plants, experience shows that the conditions f preservation are extremely varied, so that while a lignite from the

Pleistocene may have its structure perfectly preserved, another lignite from a much more recent deposit may show but few of those structural features upon which distinction of species may be supposed to rest. From this it follows that, assuming such a classification to be perfectly elaborated, its application to the determination of fossil plants must have very definite limitations, dependent upon the state of preservation of the material in hand.

In accordance with these considerations, it was originally held that any such classification, to be most efficient for all purposes thus indicated, must permit conclusive deductions to be drawn, if possible, from sections of about one centimetre square, such as might be prepared in the ordinary way for microscopic purposes, since this alone would meet the average requirements of material representing fossil plants. It is to be observed, however, that such limitations at once impose difficulties which, joined to those due to the fact that the wood alone furnishes the necessary data, might render the classification of inferior value in actual practice. The aim has, therefore, been to select if possible, those distinguishing characters which may be found in the structure of the woody parts of the stem as exposed in the usual planes of section—transverse, radial and tangential,—and to obtain conclusive proof as to their efficiency or inefficiency for the purpose stated. The results so far reached seem to justify the conclusion that for genera the characters are well defined. In this connection we may cite the results already reached by Göppert,[1] and the fact that an extended examination of woods led Solereder[2] to the conclusion that the characters to be met with are sufficiently constant to admit of distinguishing families, tribes, genera, and even species.

With these thoughts in mind, attention was directed in the first instance, toward the accumulation of authentic material—a work of slow progress, now extended over a period of sixteen years, and, with respect to some of the angiosperms, not yet completed. Within recent date, however, all the various species and varieties of the *Taxaceæ* and *Coniferæ* north of the Mexican boundary have been brought together. This fact, joined to the pre-eminent position occupied by these plants with respect to their economic importance and palæontological relations, led to their being regarded as subjects best suited to immediate investigation. The present paper, therefore, which deals with the gymnosperms only, may be regarded as the first of a series of similar treatises on the classification of the North American woods as a whole.

Incidentally to the present work, a number of foreign species have been studied, but it has been thought advisable to defer their consideration until opportunity offers for an exhaustive treatment of all exotic species.

---

[1] Foss. Conif., Leiden, 1850.

[2] Bot. Zeit., xliv., 1886, 506.

The whole number of species and varieties included in our present studies is eighty-nine, representing fourteen genera.

The present work involves no claim to originality beyond the method of working out the details. Fully twenty years ago, having due regard for the work already accomplished by various investigators, DeBary gave a clear exposition of the general basis upon which such a classification might be constructed, thereby summarizing the results already reached by Göppert, Hartig, Nördlinger and others.[1]

Notwithstanding the work already referred to, little interest appears to have centred in this line of investigation until 1880, when the Vienna Academy proposed as a subject for the Baumgartner prize of 1,000 florins "The microscopical investigation of the wood of living and fossil plants," the special object of the investigation being to ascertain characters whereby it would be possible to determine the genus and species with certainty, from microscopical sections. Since then the literature of the subject has increased considerably, the various papers either dealing with the subject as a whole or treating of some special aspect of the question, and to these reference will be made as occasion requires.

The *Coniferæ*, as a whole, have been so well investigated, that the characteristic features of their various anatomical elements are well known, and require little or no special discussion at this time. Such considerations, therefore, do not properly constitute a part of the present paper, in which we are more directly concerned with the application of anatomical facts to questions of taxonomy. It naturally follows from this that, when anatomical elements possess no diagnostic value, they do not form an element of the present discussion.

For purposes of comparison it has been held of importance that all measurements and drawings should be made under as nearly identical conditions as possible. All determinations of structure, therefore, with one exception to be noted in another place, have been made by means of Zeiss A and D objectives and ocular 4. All measurements have been made under identical conditions, while all the drawings, executed with the same combination and by means of a Zeiss camera, are upon a uniform scale of 280 diameters.

In the preparation of material for examination, as also in the examination itself, certain precautions have been observed, and to these it will be desirable to draw attention for the benefit of those who may have had but limited experience in this line of work. No complete diagnosis can be made from a single section. It is quite true that we may with certainty, and from a simple examination of a tangential section, distinguish Douglas fir from all other woods, and that we may with equal certainty separate *Pinus* and *Picea* from one another and from nearly all other genera. It is also true that from a radial section we may with certainty distinguish *Taxodium distichum* from *Sequoia* and all other genera, and that we may also separate the two species of this latter genus from one another. But comparatively few woods are thus strongly characterized, while in the genus *Pinus*, *Cupressus*, *Thuya*, etc., the distinction between one species and another often involves a consideration of several characters. Where species are thus separated by narrow lines, much judgment is needed for their differentiation, and a single section in any given direction would be wholly inadequate to meet the requirements of the case. Furthermore, the complete aspects of structure are exhibited only when sections in three directions have been made and examined—one transverse and two longitudinal—of which latter one must be radial and the other tangential. Such sections should not exceed the one five-hundredth of an inch in thickness, when, under proper treatment, they become perfectly transparent and exhibit all the various details of structure in a very satisfactory manner.

---

[1] Comp. Anat. of Phan. and Ferns.

With respect to the cutting, great care should be taken that the plane of section is exactly transverse, radial or tangential as the case may be, otherwise distortions of structure are introduced and the proper details are lost. In the case of tangential sections, it is of first importance that they should represent as large an area as possible. In stems of small diameter, such as alone may be obtained in the case of *Juniperus sabina procumbens*, or in the case of small branches, such as often represent the only available material of a fossil wood, where the total diameter is less than one inch and the curvature of the growth-rings is correspondingly short, it is often a difficult matter to secure sufficient area for a correct diagnosis. In all such cases a number of sections should be prepared for examination, since the determination of such species as *Abies nobilis*, *Abies bracteata* and *Larix occidentalis* depends in large measure upon the structure thus displayed. For section cutting I have employed a King microtome, with a knife of heavy weight and special form, and found it to be fairly satisfactory, particularly when the material is fresh or properly softened. The sections are cut to the full size of the microtome-well, and average about one centimetre square.

The sections having been properly cut, require to be exhausted of all air which they may contain. This is sometimes, especially in the spruces, a troublesome process, but it may be managed by means of the air-pump, or by the prolonged action of alcohol, when time is not an important element. The method employed in the present case has been based upon the dehydrating action of alcohol, in conjunction with the action of boiling water, since all the structures involved are of such a nature as to be subject to no alteration under such conditions. The usual procedure has been to place the sections in alcohol for ten or fifteen minutes; they are then transferred directly to boiling water for about five minutes, after which they are returned to the alcohol. One such treatment is sufficient for most woods, but in some cases the process requires to be repeated several times before the air is fully dislodged. After thorough dehydration in alcohol, the sections require to be stained. My experience has been that there are very few woods that can be successfully studied in balsam-mounts without staining. These are the *Sequoias*, most of the *Taxaceæ*, and some of the junipers—in short, those woods which possess a natural pigment in sufficient quantity to give them a pronounced colour. In all other *Coniferæ* the effect of a highly refractive medium like balsam is to render many details of structure wholly invisible or recognizable with difficulty. The stain found best suited to the purpose is a strong alcoholic solution of Bismarck brown. It has the special advantage of durability; it is applied easily and rapidly; any excess is easily reduced by the action of alcohol, and it is actinically opaque, thus making it of special value in photographic work. Some woods absorb the stain very rapidly, others but slowly, but an immersion of from three to five minutes is ample for most cases.

The sections are somewhat overstained. They are then thoroughly washed in strong alcohol and cleared in carbolic acid, which serves to reduce the stain to the proper degree of intensity. I prefer carbolic acid to other clearing agents for hard tissues, since it clears more sharply and quickly, but it demands the subsequent use of chloroform balsam for mounting, instead of xylol balsam. In the latter case xylol would require to be used as the clearing agent, but as small quantities of alcohol do not dissolve in it with readiness, the subsequent mount is sure to come out cloudy. The only other precaution to be observed is that, before transferring the section to balsam, all carbolic acid should be carefully drained off, since any excess will be sure to remain in the preparation, and after a time separate out in unsightly sphere-crystals. The mounts thus made require to be dried slowly for about three or four days, to avoid the formation of bubbles, but after that the drying may be carried on more rapidly.

In determining material, the sections should in all cases be carefully prepared as directed. Any attempt to determine either genus or species from poorly prepared material will be sure to lead to confusion. Finally, with the sections properly mounted, a complete diagnosis should be made and carefully written out. This is then employed in the determination. Too much insistance cannot be laid upon the importance of observing this rule, until one has gained a very large amount of experience, since it is a very difficult matter to correctly carry in the mind and accurately compare the large number of similar microscopic details required in the determination of a species.

Nomenclature is not a leading element in the present paper, and I have considered that in adopting the "Index Kewensis" as a standard all present requirements would be met in a satisfactory manner. When special questions have arisen, however, respecting the union or separation of genera or species, *e. g.*, the separation of *Cupressus* and *Chamæcyparis*, or the identity of *Cupressus macrocarpa* with *C. guadalupensis*, as suggested by Masters,[1] the nomenclature has been changed to meet the requirements of the particular case.

In this connection I desire to record my deep appreciation of the very large measure of assistance which has been freely offered by a large number of correspondents. To my friend, Dr. G. L. Goodale, of Harvard University; to Prof. C. S. Sargent, of the Arnold Arboretum; Dr. Trelease, of the Missouri Botanic Gardens; Dr. Douglass Campbell and Prof. Dudley, of the Leland Stanford, Jr., University; Prof. Lemmon, of San Francisco; Dr. Charles Mohr, of Mobile, Alabama; Baron F. von Mueller and Mr. Walter Hill, of Australia; Prof. John Macoun, of the Geological Survey, Ottawa; Mr. B. E. Fernow, chief of the Division of Forestry of the United States Department of Agiculture; Dr. A. W. Chapman and Dr. B. L. Robinson, curator of the Gray Herbarium of Harvard University, I am indebted for valuable assistance in securing authentic material and references. To Mr. Morrice K. Jesup, president, and Mr. Dill, secretary of the American Museum of Natural History, New York, I am under obligations for much courtesy in supplying a large amount of valuable material. To Mr. J. G. Jack, of the Arnold Arboretum, I desire to express my special acknowledgments of the assistance freely offered, and, often with much inconvenience to himself, in procuring material and supplying authentic specimens for control tests. To Miss C. M. Derick, lecturer in botany, McGill University, I am also under obligations for much assistance in the prosecution of this work.

The data for a differentiation of the *Taxaceæ* and *Coniferæ* are to be found in the occurrence of resin-passages, of isolated resin-cells and of medullary rays containing resin-passages, as also in the presence or absence of tracheids with spiral markings.

The *Coniferæ*, as a whole, are distinguished by their more or less, often strongly resinous wood. This is found in some cases to be due to the presence of numerous large channels—the resin-passages—which traverse the stem longitudinally for great distances, and such structures are always characteristic of *Pseudotsuga*, *Larix*, *Picea* and *Pinus*, more rarely appearing in an imperfectly organized form in *Sequoia* and *Abies*. On the other hand, the resinous matter is found to have its origin in isolated resin-cells, which are variously distributed either through the entire body of the growth-ring or localized along the outer face of the summer wood. In either case their presence may be at once determined by the peculiarly dark and resinous colour of the contents, or by the structure of the terminal walls wherever exposed in transverse section. The walls then show a coarsely pitted structure similar to that of a poorly formed sieve-plate. The general law of distribution shows that in those woods which have well defined resin-passages the resin-cells are wanting. Similarly, those woods which have an abundance of resin-cells show an absence of resin-passages—the one replaces the other. Exceptions to this law naturally occur. Thus, in *Pseudotsuga* and *Larix*, genera which are distinguished by their prominent resin-passages, there are also well defined resin-cells. So also in *Sequoia* and *Abies*, genera conspicuous for their resin-cells, resin-passages sometimes occur.

---

[1] "Garden and Forest," vii., 298.

Our investigations show that in all genera having resin-passages in the wood there are also resin-passages traversing the stem in a radial direction and embraced in certain of the medullary rays, which have their general form and structure correspondingly altered. Under such circumstances the rays become, as a rule, much higher and always much broader than the ordinary rays. The modification, as exhibited in a tangential section, is such that, while the terminals above and below are acute or linear, the central tract is broadened out more or less abruptly, and then consists of one large resin-passage, and usually also of much reduced parenchymatous-cells, lying immediately external to the epithelial structure, thus forming the outer limits of the tract. Such rays, which, from their form, may be designated as fusiform, in order to readily distinguish them from those of the ordinary linear and uniseriate type, are always found in association with resin-passages, which traverse the stem longitudinally. So intimate is this relation that the presence of one may always be inferred from the other. All North American species of *Taxaceæ*, without exception, show a complete absence of all three of the elements so far considered—resin-cells, resin-passages and fusiform rays. It thus becomes possible, on these grounds alone, to definitely separate this family from all the *Coniferæ*. Among the latter the genus *Pseudotsuga* stands out prominently as an almost unique instance of a case approaching the *Taxaceæ* in one of its most salient features. In all of the North American *Taxaceæ*, without exception, the tracheids are characterized by the presence of a double series of spiral bands. So distinctive are these structural features that, with one exception, they invariably point to a member of this family. In the genus *Pseudotsuga* similar spirals are to be met with as a constant element of structure, with this difference, however, that while in the *Taxaceæ* the spirals are a constant element of all the tracheids, in *Pseudotsuga* they are often entirely absent from the summer wood; they are, nevertheless, always to be met with in the spring wood. Any confusion which might otherwise arise through the presence of such spirals is at once removed by the fact that whereas in *Taxaceæ* there are no resin-passages or fusiform rays, both of these structures are characteristic of *Pseudotsuga*. Occasionally other conifers manifest a tendency to the formation of spirals. Thus in *Larix* *americana* the outer tracheids of the summer wood sometimes develop very distinct spirals; also in some of the hard pines—notably *P. taeda*—there is a decided tendency in the same direction. But in none of these cases is the development carried so far as to involve confusion with respect to the law already stated. On the basis of these considerations it becomes obvious that, on anatomical grounds, there is good reason for regarding the *Taxaceæ* and *Coniferæ* as distinct families, a conclusion which serves to materially strengthen similar deductions already derived from general morphological considerations.[1]

The *Taxaceæ* embraces only two genera within the limits of North America north of the Mexican boundary. These are *Taxus* and *Torreya*, and between them the principal differential feature is to be found in the shape and size of the ray-cells, as exposed in tangential section, and thus, to some extent also, the width of the ray. Thus in *Taxus* the cells are oblong and usually very narrow, and investigation confirms the belief that there is no essential deviation from this rule, since the most marked alteration of form occurs in those rays which become more or less two-seriate, when the cells are sometimes rather shorter and broader, and thus assume a more or less oval form. (Plate I., fig. 3.) In *Torreya*, on the other hand, the ray-cells are always much broader and larger and distinctly oval, more rarely oblong. (Plate I., fig. 5.) Supplementary differentiations also appear in the compactness of the tracheid spirals and in the general character of the transverse section. If the compact spirals of *Taxus canadensis* (Plate I., fig. 2) are compared with the somewhat distant spirals of *Torreya californica*, the distinction between these two genera is at once apparent. Similar differences exist, in a more or less pronounced degree, between other species of these genera, and they become very obvious in a comparison of *Taxus canadensis* with *Torreya taxifolia.* (Plate I., fig. 4.) A third and much less reliable, although valuable supplementary character, is to be met with in the general aspect of the wood as exposed in transverse section. In the genus *Taxus* the tracheids are chiefly small, thick-walled, variable in size, and with more or less conspicuously rounded lumens—the structure, as a whole, being rather compact. These characteristics apply with particular force to *T. canadensis* and *T. brevifolia*, but are less applicable to *T. floridana*, since the structure in this species shows a distinct approach to the characteristics of the genus *Torreya.*

In *Torreya* the tracheids are relatively large, the walls rather thin, the lumens are, as a rule, more distinctly squarish, while the structure, as a whole, is distinguishable by its rather open texture. While such differences may very correctly be associated with generic distinctions, it must be recalled that the aspect of structure in transverse section varies somewhat widely under different conditions of growth and even in different parts of the same tree, and these variations are of such a nature that it would be quite possible for the wood in a branch of *Torreya* to present much the same aspect as wood taken from a stem of *Taxus*. With these considerations in mind, it becomes possible to construct a differential key for these two genera, and this, together with a systematic diagnosis of the family and of each genus, will appear in the following pages.

---

[1] Geol. Surv. of California, Botany, ii., 109; Jour. Lin. Soc., xxx., 1.

The *Taxaceæ* and *Coniferæ* possess a number of structural features in common. These are to be found first in the transverse section, in the usually regularly radial disposition of the tracheids. In the radial section the radial walls of the tracheids of both the spring and summer wood are marked by the presence of conspicuous bordered pits. In the *Taxaceæ* these structures are relatively small, and always in one row, generally occupying the full width of the narrow tracheids. In the *Coniferæ*, on the other hand, they are, with the exception of *Juniperus*, usually large and oval or round, and not infrequently two- or three-seriate. In both families bordered pits occur on the tangential walls of the summer wood, and in a very few cases on the tangential walls of the spring wood of certain *Coniferæ*.

Apart from the details already considered as differentiating these two families, there are few anatomical features which belong distinctively to the *Coniferæ*, and they are to be regarded as of subordinate value. Thus in transverse section the tracheids, except in *Juniperus*, are, as a rule, much larger, and there is often a more marked and abrupt contrast between the spring and summer woods. In the radial section the *Coniferæ* commonly show Sanio's bands, which are wholly wanting in the *Taxaceæ*, so far as it is possible to determine from our present investigations.

Anatomical considerations show that the sequence of genera and also the limitations of those groups, as defined on the basis of general morphology, require some readjustment. It will, therefore, be desirable to consider somewhat in detail the various points of affinity which justify the arrangement embodied in the present treatise.

The four genera *Libocedrus*, *Cupressus*, *Thuya* and *Juniperus* fall into a natural group, of which the common characteristics are the presence of more or less numerous resin-cells, the chiefly simple pits on the lateral walls of the ray-cells, the thin or sparingly pitted terminal walls of the ray-cells, and the absence of resin-passages. A more critical examination of the distribution of the resin-cells shows that *Libocedrus* and *Juniperus* approach one another somewhat closely in the fact that these elements are disposed in tangential bands, while in both *Thuya* and *Cupressus* they are commonly scattering and often appear only in somewhat distant growth-rings. The affinity between the first two genera is also greatly strengthened by the great similarity of the terminal walls of the ray-cells. There is an important point of divergence, however, in the fact that while in *Libocedrus* the pits on the lateral walls of the ray-cells are simple, in *Juniperus* they are more or less conspicuously bordered, a feature which tends strongly to give this latter genus a decided affinity with *Taxodium* and *Sequoia*. The separation of these genera from *Thuya* and *Cupressus* thus rests upon well defined differences in the distribution of the resin-cells and the structure of the terminal walls of the ray-cells. On the other hand, while *Libocedrus* approaches them through the character of the pits on the lateral walls of the ray-cells, by the same character *Juniperus* is separable from both of these genera and finds its affinity with *Sequoia* and *Taxodium*. A critical comparison of the remaining generic characters will permit of more exact deductions as to the precise relations in which these genera stand to one another.

LIBOCEDRUS.

Transverse. Summer wood thin, rather dense, usually showing a median layer of more dense structure.

Radial. The terminal walls of the ray-cells straight or somewhat curved, entire, locally thickened or even coarsely pitted; the pits on the lateral walls of the ray-cells small and simple. Pits on the tangential walls of the summer tracheids chiefly small and not very numerous.

JUNIPERUS.

Transverse. Summer wood thin but very dense.

Radial. Terminal walls of the ray-cells thin and entire, more rarely somewhat pitted; the pits on the lateral walls of the ray-cells often with a more or less obvious border. Pits on the tangential walls of the summer tracheids chiefly small and not very numerous.

THUYA.

Transverse. Summer wood thin, the structure rather dense.

Radial. The terminal walls of the ray-cells thin and not pitted or locally thickened, usually much curved. Pits on the tangential walls of the summer tracheids small to medium.

Tangential. Ordinary rays narrow, the cells oblong, often very narrow, more rarely oval.

CUPRESSUS.

Transverse. Summer wood very thin, often barely distinguishable, the structure open throughout.

Radial. Terminal walls of the ray-cells commonly curved, thin and entire or often locally thickened. Pits on the tangential walls of the summer tracheids medium to large.

Tangential. Ray-cells chiefly broad, oval, or even transversely oval, the rays often more or less two-seriate.

The two genera, *Thuya* and *Cupressus*, are very closely connected, and for a long time morphologists have been unable to agree as to their precise limitations. The *Thuya occidentalis* of Linnæus and *T. gigantea* of Nuttall, appear to have been referred to this genus without exception. *Cupressus thyoides*, of Linnæus, was referred by Spach to *Chamæcyparis sphæroidea*, by Sprengel to *Thuya sphæroidea* and by Richard to *T. sphæroidalis*, a name which has been adopted by the Index Kewensis as authoritative. *Cupressus nutkænsis* of Hooker or *C. nootkatensis* of Lambert, was also referred to the same genus by Trautvetter under the species *C. americana*. By Carriere it was referred to the genus *Thuyopsis* and at different times to *T. borealis* and *T. cupressoides*. Both Spach and Walpers referred it to the genus *Chamæcyparis*, and Fischer also recognized the same genus but applied the specific name of *C. excelsa*. The most recent ruling, as embodied in the Index Kewensis, indicates that Lambert's name of *Cupressus nootkatensis* is to be regarded as the authoritative one.

Cupressus embraces five species which have been invariably referred to it, *C. macrocarpa*, *C. Goveniana*, *C. Macnabiana*, *C. guadalupensis* and *C. arizonica*. *Cupressus Lawsoniana* of Murray has been referred to the same genus by both Gordon and Kellogg, but it has been assigned to *Chamæcyparis* by Parlatore, Carriere and Torrey. By the Index Kewensis, Murray's name of *Cupressus Lawsoniana* is regarded as the one which holds the greatest claim to recognition. It thus appears that although recent writers, such as Sargent, have recognized *Chamæcyparis* as a distinct genus, the tendency has been to divide it up among *Thuya* and *Cupressus*. It thus becomes obvious that evidence derived from anatomical data, which may tend to throw its weight in favour of one or the other of these views, will be of special value.

An examination of the characters already detailed for the genera under consideration will show that the essential distinction rests upon the shape of the ray-cells in tangential section, and upon the character of the terminal walls of the ray-cells. Thus in *Thuya* the ray-cells are distinctly oblong, often quite narrow, more rarely oval, while the terminal walls of the ray-cells are conspicuously devoid of pits or local thickenings. In *Cupressus*, on the other hand, the rays are distinctly broader, the cells are oval, or even transversely oval, rarely oblong. The walls are also much thicker as a rule. The terminal walls of the ray-cells are thin and often entire, but they also frequently show very obvious local thickenings. These characters are well defined, and, so far as a large amount of material will permit a definite conclusion, constant. These characters, therefore, may safely be taken as marking the limitations of the genera. On this basis, *Chamæcyparis nutkænsis* of Spach must be restored to the genus *Cupressus* under Lambert's name of *C. nootkatensis*. The genus *Chamæcyparis* thus disappears altogether, a change which is quite in accord with the tendency at present prevalent among morphologists.

It may also be pointed out in this connection that although characters derived from the aspect of the transverse section are not of leading importance, yet they may serve to confirm differentiations based on other data. We thus find that in *Thuya* as a whole the tracheids are distinguished by their large size, squarish forms and thin walls. In *Cupressus*, on the other hand, they are usually more rounded, somewhat smaller and generally thicker walled. These differences not only agree with the limitations already assigned to *Thuya* and *Cupressus*, but they show that the latter approaches the former through *C. thyoides*. It would thus appear that, on anatomical grounds, there is a very close relationship between *Thuya* and *Cupressus*, and that the limitations of the two are not marked by strongly defined characters. This becomes more apparent when it is recalled that *Cupressus thyoides*, on anatomical grounds alone, could safely be referred to *Thuya*, when it would become *T. sphæroidalis*, but when we consider the weight of evidence to be derived from both the external and internal characters, it becomes clear that this species belongs to *Cupressus*.

From a paper published since these conclusions were reached, it is interesting to note that Dr. Masters has arrived at the same results, but from data derived wholly from a study of the external characters.[1]

With respect to the genus *Cupressus* as now constituted, it may be pointed out that it is separable into two distinct groups, the first of which may be designated as *Chamæcyparis*, and the second as *Cupressus* proper.[2] The former includes *C. thyoides*, *C. nootkatensis* and *C. Lawsoniana*. The distinguishing feature is to be found in the character of the pits on the tangential walls of the summer tracheids, which are narrowly lenticular and not very large. The second section embraces all the remaining species which have heretofore been recognized under this genus. The distinguishing feature is found in the conspicuously large and broadly lenticular pits on the tangential walls of the summer tracheids.

Taxodium and *Sequoia* approach one another closely in the fact that the pits on the lateral walls of the ray-cells are conspicuously bordered, while the same element also serves as the basis of specific distinction. Thus in *Taxodium* the pits are round and the orifice is narrowly oblong, the border therefore broad; while in *Sequoia* the pits are distinctly oval or elliptical and the orifice broadly oblong, the border thus becoming much narrower, and sometimes even obscure. These differences are very well defined and constant, and admit of no doubt as to the particular genus. Both of these genera approach *Juniperus* in the presence of prominent resin-cells, as well as in the fact that these elements are disposed in tangential bands. To this must also be added the fact, already pointed out, that a further affinity is based upon the occurrence in all three of bordered pits on the lateral walls of the ray-cells, and similarity of structure in the terminal walls of the ray-cells. The occurrence of occasional resin-passages in *Sequoia sempervirens*, and a similar occurrence of imperfectly formed resin-passages in *Abies nobilis*, point to the fact that there is a strong point of contact between these two genera.

---

[1] Journ. Lin. Soc., xxi., 312.

[2] Dr. Masters's results again accord with my own in the subdivision of the genus *Cupressus*, although, on anatomical grounds, I prefer to reverse the order.

The relation between *Sequoia* and *Abies* thus indicated is greatly strengthened in other ways, as in the absence of resin-passages and fusiform rays, together with the occurrence of isolated resin-cells. *Abies*, on the other hand, approaches the genus *Tsuga*, not only in a closer general resemblance of the structure as displayed in transverse section, but in the peculiar distribution of the resin-cells on the outer face of the summer wood, a character which is likewise common to *Pseudotsuga* and *Larix*. In this last character a certain affinity with *Picea* is indicated, since in the latter the resin-cells are wholly wanting, while in *Abies* they have so far disappeared as to be very scattering and often rather obscure. Nevertheless the weight of evidence shows that there is no direct relation with *Picea*, more especially when to the facts already stated we add those elements to be derived from the structure of the ray. In *Sequoia* and *Taxodium* there are no ray-tracheids. In *Tsuga*, on the other hand, the tracheids constitute a very prominent feature in the composition of the medullary rays. In *Abies*, all the North American species, with the single exception of *A. balsamea*, as long since pointed out by DeBary,[1] are devoid of tracheids, and in this single species these structures are to be found but sparingly. The systematic position of this genus in relation to *Sequoia* on the one hand, and to *Tsuga* on the other, is thus a matter of well defined certainty.

The three genera, *Tsuga*, *Pseudotsuga* and *Larix*, possess the common characteristic of having their resin-cells scattering on the outer face of the summer wood. They are also joined by the presence of ray-tracheids. *Tsuga* nevertheless stands apart, and finds alliance with *Abies*, *Sequoia* and others of that group, through the absence of resin-passages and fusiform rays, elements which are not only prominent in *Pseudotsuga* and *Larix*, but also in *Picea* and *Pinus*. *Pseudotsuga*, *Larix* and *Picea* are yet more closely related by reason of the great similarity of the fusiform rays. These structures, within the limits of this group, are generally distinguished by the rather abrupt contraction of the central tract into linear terminals, which often become much prolonged. The cells are thick-walled, and the resin-passage is chiefly devoid of thyloses, while the epithelium-cells are thick-walled and form a distinctly undulating outline to the central passage or space. A separation of these three genera then becomes possible, in the first instance, from the fact that in *Picea* there is a total absence of resin-cells—a fact which serves to give it direct connection with *Pinus*. *Pseudotsuga* is the most clearly defined of all genera by reason of its spiral tracheids—a feature which serves to differentiate it not only from *Larix* but from all other genera without question. In cases of possible doubt, however, such as might arise through the removal of the spirals by decay, it may be borne in mind that a further differentiation appears in the large size of the resin-passages in the fusiform rays of *Larix*, while in *Pseudotsuga* they are small and often nearly closed.

---

[1] Com. Anat., 1884, p. 490.

The genus *Pinus* stands by itself as a well-defined group which it is impossible to confound with any other genus. As already pointed out, it possesses certain characteristics in common with *Picea*, *Larix* and *Pseudotsuga*, by reason of the presence of resin-passages and fusiform rays, as also in the invariable presence of ray-tracheids. It is unique, however, not only in the character of the fusiform rays, but in the nature of the pits on the lateral walls of the ray-cells and in the structure of the cells themselves. To these features may also be added the fact that the resin-passages are large, always with thyloses, and the epithelium-cells are thin-walled, forming an entire boundary to the central space. Within its own limits the genus presents certain well-defined differences, which permit of its separation into two subordinate groups or subgenera. The first of these divisions is distinguished by the presence of bordered pits on the tangential walls of the summer wood, while the second is distinguished by the entire absence of these elements.

From the relations thus indicated, the various genera have been arranged in such sequence as to exhibit as nearly as possible their true genetic affinities, and the order given in the following synopsis may be taken as expressing these relations in their principal aspects. I am fully sensible, however, of the many imperfections which must enter into a work of this nature—a work which is announced for the first time, and has not yet gained that measure of solidity which can only come from its actual application to the purposes for which it is intended. It is, therefore, my hope that those who may have occasion to use it will report any serious deficiencies or point out any alterations which may tend to increase its working efficiency.

TAXACEÆ.

Transverse. Wood wholly devoid of resin-passages and of isolated resin-cells; the tracheids in more or less regular, radial rows, chiefly small.

Radial. Tracheids with conspicuous bordered pits on the radial walls, and small, often inconspicuous bordered pits on the tangential walls of the summer wood; the spiral bands narrow, in double series. Ray tracheids wholly wanting.

Tangential. Medullary rays of one kind only, chiefly one, rarely two-seriate in part.

SYNOPSIS OF GENERA.

1. Ray-cells (tangential) narrowly oblong.

Tracheids (transverse) chiefly thick-walled and variable, the lumens usually conspicuously rounded, the structure somewhat compact (except *T. floridana*), the spirals rather close.

1. TAXUS.

2. Ray-cells (tangential) broad, oval or oblong.

Tracheids (transverse) large, chiefly squarish and rather thin-walled, the structure rather open throughout; the spirals rather open.

2. TORREYA.

I. TAXUS, Tourn.

Transverse. Growth-rings variable and often unconformable. Summer wood chiefly dense and conspicuous, though often very thin; tracheids small and more or less rounded; the structure chiefly dense, more rarely open (*T. floridana*), with large and squarish tracheids.

Radial. Spirals of the tracheids rather close.

Tangential. Ray-cells narrowly oblong.

SPECIES.

T. canadensis, Willd.
T. brevifolia, Nutt.
T. floridana, Nutt.

2. TORREYA, Arnott.

Transverse. Growth-rings rather thin, often variable. Summer wood usually very thin; the tracheids rather large, chiefly squarish, the structure open throughout.

Radial. Tracheids with much more open spirals.

Tangential. Ray-cells large, broadly oval or oblong.

SPECIES.

T. californica, Torr.
T. taxifolia, Arnott.

CONIFERÆ.[1]

Transverse. Wood with or without resin-passages, often bearing isolated resin-cells; the tracheids in more or less regular, radial rows, chiefly large (except *Juniperus*).

Radial. Tracheids rarely with spirals, but their radial walls bearing conspicuous bordered pits in 1–3 rows, sometimes also appearing on the tangential walls, chiefly of the summer wood; often showing confluent infoldings of the tangential walls, which thus form more or less extended radial series of bands—Sanio's bands. Medullary rays with or without tracheids.

Tangential. Medullary rays chiefly linear and uni-seriate, or two to three-seriate in part, sometimes with the central portion or the entire height of the ray so expanded as to make it fusiform, when the central tract consists of a single resin-passage, with or without thyloses.

SYNOPSIS OF GENERA.

A.—Resin-passages and fusiform rays present.

1. Fusiform rays narrow, the terminals chiefly abruptly and long linear; the cells rather small and thick-walled. Resin-passages with thick-walled epithelium and chiefly without thyloses.

Tracheids (radial) with spirals, at least in the spring wood.
  Resin-cells scattering on the outer face of the summer wood.
9. PSEUDOTSUGA.

Tracheids wholly without spirals (radial).
  Pits on the tangential walls of the summer wood.
    Resin-cells present, but scattering on the outer face of the summer wood.
10. LARIX.
    Resin-cells wholly wanting.
11. PICEA.

2. Fusiform rays (tangential) chiefly broad, the cells large, the resin-passages broad, with thin-walled epithelium and strongly developed thyloses.

Resin-cells wholly wanting.
  Pits on the tangential walls of the summer wood.
12. PINUS. (Sec. 1.)
  Pits on the tangential walls wholly wanting.
12. PINUS. (Sec. 2.)

3. Fusiform rays (tangential) wholly wanting. Resin-passages (transverse) when present, usually in compact rows on the outer face of distant growth-rings, imperfectly formed.

---

[1] The species enumerated in the following synopsis are to some extent provisional.

Resin-cells prominent.

Pits on the lateral walls of the ray-cells usually with a conspicuous border, the orifice very large, oblong.

6. SEQUOIA SEMPERVIRENS.

Resin-cells remote and more or less obscure on the outer face of the summer wood.

Pits on the lateral walls of the ray-cells simple, small, elliptical.

7. ABIES.
(*A. bracteata* and *nobilis.*)

B.—Resin-passages and fusiform rays wholly wanting.

Resin-cells (transverse) prominent and in more or less conspicuous tangential bands, sometimes of distant growth rings or widely scattering.

Terminal walls of the ray-cells sparingly pitted.

Pits on the lateral walls of the ray-cells large, with a distinct border.

Pits on the lateral walls of the ray-cells round, the narrowly oblong orifice distinctly diagonal.

5. TAXODIUM.

Pits on the lateral walls of the ray-cells oval, the broadly oblong orifice often parallel to the cell-axis, the border often narrow, sometimes obscure.

6. SEQUOIA.

Pits on the lateral walls of the ray-cells wholly simple or with an inconspicuous border, chiefly small.

Resin-cells (transverse) numerous, chiefly in conspicuous tangential bands.

Pits on the tangential walls (radial) of the summer wood, very large and numerous.

4. LIBOCEDRUS.

Pits on the tangential walls (radial) of the summer wood chiefly small, not very numerous.

3. JUNIPERUS.

Terminal walls of the ray-cells entire or locally thickened, commonly curved.

Resin-cells (transverse) rarely in bands, chiefly widely scattering, sometimes wanting.

Ray-cells (tangential) narrowly oblong.

1. THUYA.[1]

Rays (tangential) rather broad, the cells round, oval or transversely oval.

2. CUPRESSUS.

---

[1] In *Thuya* and *Cupressus* the resin-cells are sometimes very widely scattering, so that a given section may not show them.

Resin-cells (transverse) not prominent, remote and more or less obscure on the outer face of the summer wood.

Terminal walls of the ray-cells more or less coarsely pitted.

Rays (radial) with conspicuous tracheids.

8. TSUGA.

Rays (radial) wholly without tracheids.

(An exception is found in *A. balsamea*, which usually shows a few small tracheids.)

7. ABIES.

1. THUYA, Tourn.

Transverse. Summer wood thin, rather dense. Resin-passages wholly wanting. Resin-cells more or less prominent, but often widely scattering. Tracheids distinctly squarish throughout and thin-walled.

Radial. Ray tracheids wholly wanting. Ray-cells conspicuously contracted at the ends, the terminal walls thin and not pitted or locally thickened, usually much curved. Pits on the tangential walls of the summer tracheids only, and small to medium. Tracheids wholly without spirals.

Tangential. Fusiform rays wholly wanting. Ordinary rays narrow, medium to low, strictly uni-seriate, the cells chiefly narrowly oblong, more rarely oval, barely, if at all, resinous.

SPECIES.

1. *T. occidentalis*, L.
2. *T. gigantea*, L.

2. CUPRESSUS, Tourn.

Transverse. Summer wood very thin, often barely distinguishable, the structure open throughout. Resin-passages none. Resin-cells prominent, rather numerous in tangential rows, scattering or even apparently wanting.

Radial. Rays chiefly without tracheids. Terminal walls of the ray-cells thin and entire, often locally thickened, very commonly curved. Tracheids wholly without spirals.

Tangential. Fusiform rays wholly wanting. Cells of the rays chiefly broad, oval or even transversely oval, resinous; the rays more or less two-seriate.

SPECIES.

Sub-genus *CHAMÆCYPARIS*,

1. *C. Lawsoniana*, Murr.
2. *C. thyoides*, L.
3. *C. nootkatensis*, Lamb

Sub-genus *CUPRESSUS*,

4. *C. macrocarpa*, Hartw.
5. *C. arizonica*, Greene.
6. *C. guadalupensis*, Wats.
7. *C. Macnabiana*, Murr.
8. *C. Goveniana*, Gord.

3. Juniperus, L.

Transverse. Growth-rings generally narrow, often unconformable and coalescent on the narrow side. Summer wood very thin but dense. Resin-passages wholly wanting. Resin-cells rather numerous, prominent, and chiefly in tangential bands, often giving rise to the appearance of secondary growth-rings.

Radial. Rays chiefly without tracheids, very numerous, often very resinous. Ray-cells chiefly straight, the terminal walls thin and entire, more rarely somewhat pitted, the pits on the lateral walls often with a more or less obvious border. Tracheids wholly without spirals.

Tangential. Fusiform rays wholly wanting. Ordinary rays one to two-seriate, the cells oval, chiefly broad.

Species.

1. *J. californica*, Carr.
" " var. *utahensis*, Carr.
2. *J. pachyphlœa*, Torr.
3. *J. virginiana*, L.
4. *J. occidentalis*, Hook.
J. occidentalis, var. *conjugens*, Engel.
" " var. *monosperma*, Engel.
5. *J. communis*, L.
6. *J. sabina*, L.
" " var. *procumbens*, Pursh.

4. Libocedrus, Endl.

Transverse. Summer wood thin, rather dense, usually showing a median layer of denser structure. Resin-passages wholly wanting. Resin-cells numerous and in conspicuous tangential bands.

Radial. Rays without tracheids. The terminal walls of the ray-cells straight or somewhat curved, entire, locally thickened, or even somewhat coarsely pitted; the lateral walls with small and simple pits Tracheids wholly without spirals.

Tangential. Rays of one kind only.

Species.

1. *L. decurrens*, Torr.

5. Taxodium, Rich.

Transverse. Growth-rings rather broad, the summer wood about one third the spring wood. Resin-passages none. Resin-cells numerous, prominent and scattering or in tangential bands.

Radial. Rays without tracheids. Ray-cells more or less conspicuously contracted at the ends; the lateral walls with conspicuously bordered pits, the orifice narrow. Tracheids wholly without spirals.

Tangential. Fusiform rays none. Ordinary rays one-seriate, the cells broadly oval.

Species.

1. *T. distichum*, Rich.

6. SEQUOIA, Endl.

Transverse. Growth-rings chiefly narrow, the summer wood distinct but thin. Resin-passages wanting or rarely present, and then imperfectly formed and in compact rows (*S. sempervirens*). Resin-cells scattering, chiefly in the spring wood.

Radial. Rays without tracheids. Ray-cells with conspicuous, oval, narrowly bordered pits, the oblong orifice often parallel to the cell-axis. Pits sometimes on the tangential walls of both spring and summer woods. Tracheids wholly without spirals. Terminal walls of the ray-cells rarely, if at all, pitted.

Tangential. Fusiform rays wholly wanting. Ordinary rays one to two-seriate, the cells broadly oval, chiefly large.

SPECIES.

1. *S. gigantea*, Decaisne.
2. *S. sempervirens*, Endl.

7. ABIES, Link.

Transverse. Growth-rings usually broad, with no very clear distinction between the spring and summer woods. Resin-passages rarely present (*A. nobilis* and *A. bracteata*). Resin-cells remote and usually obscure on the outer face of the summer wood.

Radial. Ray tracheids wanting, except in *A. balsamea.* Parenchyma ray-cells generally straight in the summer wood ; the terminal walls strongly pitted. Tracheids wholly without spirals.

Tangential. Fusiform rays wholly wanting.

SPECIES.

1. *A. balsamea*, Mill.
2. *A. Fraseri*, Lindl.
3. *A. lasiocarpa*, Hook.
4. *A. bracteata*, Hook. and Arn.
5. *A. nobilis*, Lindl.
6. *A. magnifica*, Murr.
7. *A. amabilis*, Forb.
8. *A. concolor*, Lindl. and Gord.
9. *A. grandis*, Lindl.

8. TSUGA, Carr.

Transverse. Growth-rings usually thin, the summer wood prominent. Resin-passages wholly wanting. Resin-cells usually remote, and often more or less obscure on the outer face of the summer wood.

Radial. Ray tracheids prominent but narrow. Ray-cells generally resinous, more or less conspicuously contracted at the ends, the terminal walls strongly pitted ; the upper and lower walls entire or imperfectly pitted, often thickened at the ends of the cells, so as to make the latter appear strongly contracted. Tracheids wholly without spirals.

Tangential. Fusiform rays wholly wanting.

SPECIES.

1. *T. Mertensiana*, Carr.
2. *T. canadensis*. Carr.
3. *T. caroliniana*, Engel.
4. *T. Pattoniana*, Engel.

9. PSEUDOTSUGA, Carr.

Transverse. Growth-rings and summer wood very variable. Resin-passages present and usually without thyloses, but with thick-walled epithelium. Resin-cells more or less numerous on the outer face of the summer wood.

Radial. Ray tracheids present. Ray-cells straight or contracted at the ends; the terminal walls thick and more or less coarsely pitted. Wood tracheids with rather close spirals. Pits on the tangential walls of the summer wood only.

Tangential. Fusiform rays present, generally narrow, the central tract of one small resin-passage without thyloses, but with small, thick-walled epithelial cells.

SPECIES.

1. *P. Douglasii*, Carr.
" " var. *macrocarpa*, Engel.

10. LARIX, Tourn.

Transverse. Summer wood prominent, usually dense; the transition from the spring wood more or less abrupt. Resin-passages without thyloses, but with thick-walled and small but conspicuous epithelial cells. Resin-cells rather frequent but scattering, on the outer face of the summer wood.

Radial. Ray tracheids prominent. Ray-cells contracted at the ends, the upper and lower walls thick and entire or distinctly pitted; the lateral walls with simple or bordered pits; the terminal walls thick and strongly pitted. Tracheids wholly without spirals.

Tangential. Fusiform rays prominent, usually high and narrow; the cells small and thick-walled; the central tract small, and in branches, often more or less completely obliterated. A well-defined genus, at once distinguished by the narrow and often high fusiform rays, and the resin-cells scattering on the outer face of the summer wood.

SPECIES.

1. *T. occidentalis*, Nutt.
2. *L. americana* Michx.
3. *L. Lyalli*, Parl.

11. PICEA, Link.

Transverse. Growth-rings either broad or narrow. Transition from the spring to the summer wood gradual. Resin-passages with or without thyloses, but with thick-walled epithelial cells conspicuous. Resin-cells wholly wanting.

Radial. Ray tracheids conspicuous, narrow. Ray-cells contracted at the ends or straight, the terminal walls strongly pitted. Wood tracheids wholly without spirals.

Tangential. Fusiform rays with linear and often prolonged terminals, the cells small and thick-walled, the central tract of one small resin-passage without, more rarely with, thyloses, but with thick-walled epithelium. Cells of the ordinary ray oblong, more rarely oval, the walls medium.

Species.

1. *P. rubra*, Link.
2. *P. nigra*, Link.
3. *P. alba*, Link.
4. *P. sitchensis*, Trautv. and Mey.
5. *P. pungens*, Engelm.
6. *P. Engelmanni*, Engel.

12. Pinus, Tourn.

Transverse. Growth-rings chiefly broad. Summer wood variable, but usually more or less prominent. Resin-passages prominent but scattering, with thin-walled and variable epithelium, and with prominent thyloses. Resin-cells wholly wanting.

Radial. Ray tracheids prominent and always limiting the ray, often interspersed, sometimes prominent; the upper and lower walls often dentate, the teeth sometimes united across the tracheid so as to form more or less prominent reticulations. Ray-cells of one or two kinds. Bordered pits on the tangential walls of the summer tracheids either numerous or wholly wanting. Tracheids without spirals.

Tangential. Rays of two kinds; the fusiform rays chiefly large and broad, the cells of the inflated portion chiefly large and mostly thin-walled, the central tract of one large resin-passage with thyloses. Ordinary rays almost strictly uni-seriate.

Species.

1. Pits on the tangential walls of the summer wood.

1. *P. flexilis*, James.
2. *P. monticola*, Dougl.
3. *P. Lambertiana*, Dougl.
4. *P. albicaulis*, Engel.
5. *P. reflexa*, Engel.
6. *P. strobus*, L.
7. *P. Parryana*, Engel.
8. *P. cembroides*, Zucc.
9. *P. monophylla*, Torr. and Fren.
10. *P. Balfouriana*, Murr.
" " var. *aristata*, Engel.
11. *P. edulis*, Engel.

2. Pits on the tangential walls of the summer wood wanting.

12. *P. resinosa*, Ait.
13. *P. Murrayana*, Balf.
14. *P. arizonica*, Engel.
15. *P. Coulteri*, D. Don.
16. *P. Sabiniana*, Dougl.
17. *P. chihuahuana*, Engel.
18. *P. Jeffreyi*, Murr.
19. *P. ponderosa*, Dougl.
" " var. *scopulorum*, Engl.
20. *P. muricata*, D. Don.
21. *P. tuberculata*, Gord.
22. *P. Torreyana*, Parry.
23. *P. insignis*, Dougl.
24. *P. contorta*, Dougl.
25. *P. glabra*, Walt.
26. *P. inops*, Ait.
27. *P. rigida*, Mill.
28. *P. pungens*, Michx, f.
29. *P. serotina*, Michx.
30. *P. taeda*, L.
31. *P. clausa*, Vasey.
32. *P. palustris*, Mill.
33. *P. Banksiana*, Lamb.
34. *P. echinata*, Mill.
35. *P. cubensis*, Griseb.

DESCRIPTION OF FIGURES.

PLATE I.

Fig. 1.—*Taxus brevifolia.* Tangential view of a medullary ray, showing the sometimes two-seriate form and the broadly oblong cells. × 210.

Fig. 2.—*Taxus canadensis.* Radial view of the spring wood, showing the rather close spirals. × 210.

Fig. 3.—*Taxus canadensis.* Tangential view of a medullary ray, showing the narrowly oblong cells. × 210.

Fig. 4.—*Torreya taxifolia.* Radial view of the spring wood, showing the rather distant spirals. × 210.

Fig. 5.—*Torreya taxifolia.* Tangential view of a medullary ray, showing the rather broad, oval cells. × 210.

Fig. 6.—*Libocedrus decurrens.* Radial section through the summer wood, showing the numerous large pits on the tangential walls. × 210.

Figs. 7 and 8.—*Libocedrus decurrens.* Radial sections of medullary rays, showing the form of the ray-cells and the structure of the terminal walls. × 210.

Fig. 9.—*Thuya occidentalis.* Tangential view of a medullary ray, showing the narrowly oblong cells. × 210.

Fig. 10.—*Thuya gigantea.* Radial view of a medullary ray, showing the form of the cells and the simple terminal walls. × 210.

Fig. 11.—*Thuya gigantea.* Radial section through the summer wood, showing the nature of the pits on the tangential walls. × 210.

Fig. 12.—*Thuya gigantea.* Tangential section of a medullary ray, showing the narrowly oblong cells. × 210.

Fig. 13.—*Cupressus Macnabiana.* Radial section of a medullary ray, showing the form of the cells and the terminal walls, with local thickenings. × 210

Fig. 14.—*Cupressus macrocarpa.* Radial section of the summer wood, showing the large and broadly lenticular pits on the tangential walls. × 210.

Fig. 15.—*Cupressus macrocarpa.* Tangential section, showing the broad ray-cells. × 210.

Fig. 16.—*Cupressus arizonica.* Tangential section of a medullary ray, showing the broad, transversely oval and often resinous cells. × 210.

Fig. 17.—*Juniperus virginiana.* Radial section of a medullary ray, showing the straight cells and terminal walls without pits. × 210.

PLATE II.

Fig. 1.—*Juniperus occidentalis.* Radial section of a medullary ray, showing the strongly pitted terminal walls. × 210.

Fig. 2.—*Juniperus occidentalis.* Tangential section of a medullary ray, showing the broad and often resinous cells. × 210.

Fig. 3.—*Sequoia gigantea.* Radial section of a medullary ray, showing the character of the terminal walls and the nature of the pits on the lateral walls. × 210.

Fig. 4.—*Sequoia sempervirens.* Radial section through the summer wood, showing the nature of the pits on the tangential walls. × 210.

Fig. 5.—*Sequoia sempervirens.* Tangential section, showing the very broad ray-cells. × 210.

Fig. 6.—*Taxodium distichum.* Radial section through a medullary ray, showing the form of the cells and the nature of the pits on the lateral walls. × 210.

Fig. 7.—*Tsuga Mertensiana.* Transverse section through the summer wood, showing a single resin-cell on the outer face.

Fig. 8.—*Tsuga canadensis.* Radial section, showing the strongly pitted terminal walls of the ray-cells. × 210.

Fig. 9.—*Pseudotsuga Douglasii.* Tangential section, showing the structure of the fusiform ray, the resin-passage showing thick-walled epithelium cells. × 210.

Fig. 10.—*Pseudotsuga Douglasii macrocarpa.* Radial section of a medullary ray, showing the character of the terminal walls and the pits on the lateral walls. × 210,

Fig. 11.—*Larix americana.* Transverse section through the summer wood, showing a single resin-cell distinguished by exposure of the pitted terminal wall. × 210.

Fig. 12.—*Picea alba.* Radial section of a medullary ray, showing the nature of the terminal walls, and tracheids limiting the ray above and below × 210.

Plate III.

Fig. 1.—*Larix americana.* Tangential section of a medullary ray, showing resinous thick-walled cells and the resin-passages with thick-walled epithelium. × 210.

Fig. 2.—*Picea nigra.* Tangential section of a medullary ray, showing characteristic features of structure. × 210.

Fig. 3.—*Pinus albicaulis.* Tangential section of a fusiform ray, showing characteristic features of structure, the resin-passages with thyloses and rather thin-walled epithelium cells. × 2I0.

Fig. 4.—*Pinus palustris.* Tangential section of a fusiform ray, showing one aspect of structure in which the very thin-walled cells have been broken out. × 210.

Fig. 5.—*Pinus reflexa.* Radial section of a medullary ray, showing characteristic features of the first section of the genus *Pinus ;* the lateral walls of the cells with very large pits, the rays limited above and below, by tracheids. × 210.

Fig. 6.—*Pinus reflexa.* Tangential section of a fusiform ray, showing the large, thin-walled cells and the imperfectly formed resin-passages. × 210.

Fig. 7.—*Pinus serotina.* Radial section of a medullary ray, showing characteristic features of the second section of *Pinus ;* the high cells with lenticular or oval pits, the limiting tracheids above and below with strongly dentate walls. × 210.

Fig. 8.—*Pinus clausa.* Tangential section of a fusiform ray, showing characteristic features of structure. × 210.

Fig. 9.—*Pinus Balfouriana.* Radial section of a medullary ray, showing characteristic features of structure of the second section of *Pinus ;* the walls of the limiting tracheids edentate. × 210.

Fig. 10.—*Pinus cubensis.* Tangential section of a medullary ray, showing one aspect of the ordinary rays; the parenchyma cells both thick and thin-walled, the terminal tracheids high, oblong. × 210.

PLATE IV.

Fig. 1.—*Taxus brevifolia.* Transverse section, showing the small, rounded tracheids and the rather dense structure. × 55.

Fig. 2.—*Torreya taxifolia.* Transverse section, showing the rather squarish tracheids and the rather open structure. × 55.

PLATE V.

Fig. 1.—*Cupressus macrocarpa.* Transverse section, showing the open structure, the thin summer wood and the scattering resin-cells on the inner face of the spring wood. × 55.

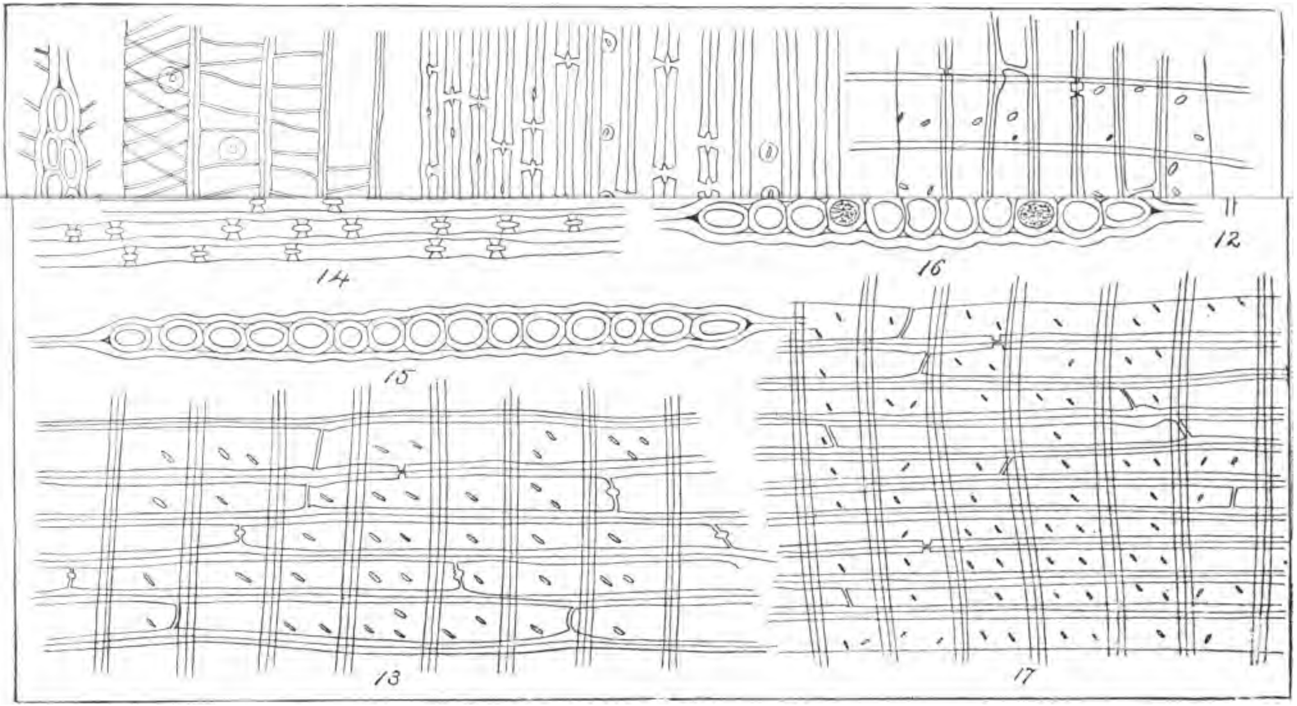
Fig. 2.—*Juniperus californica utahensis.* Transverse section, showing the very thin summer wood and the resin-cells in open bands near the summer wood. × 55.

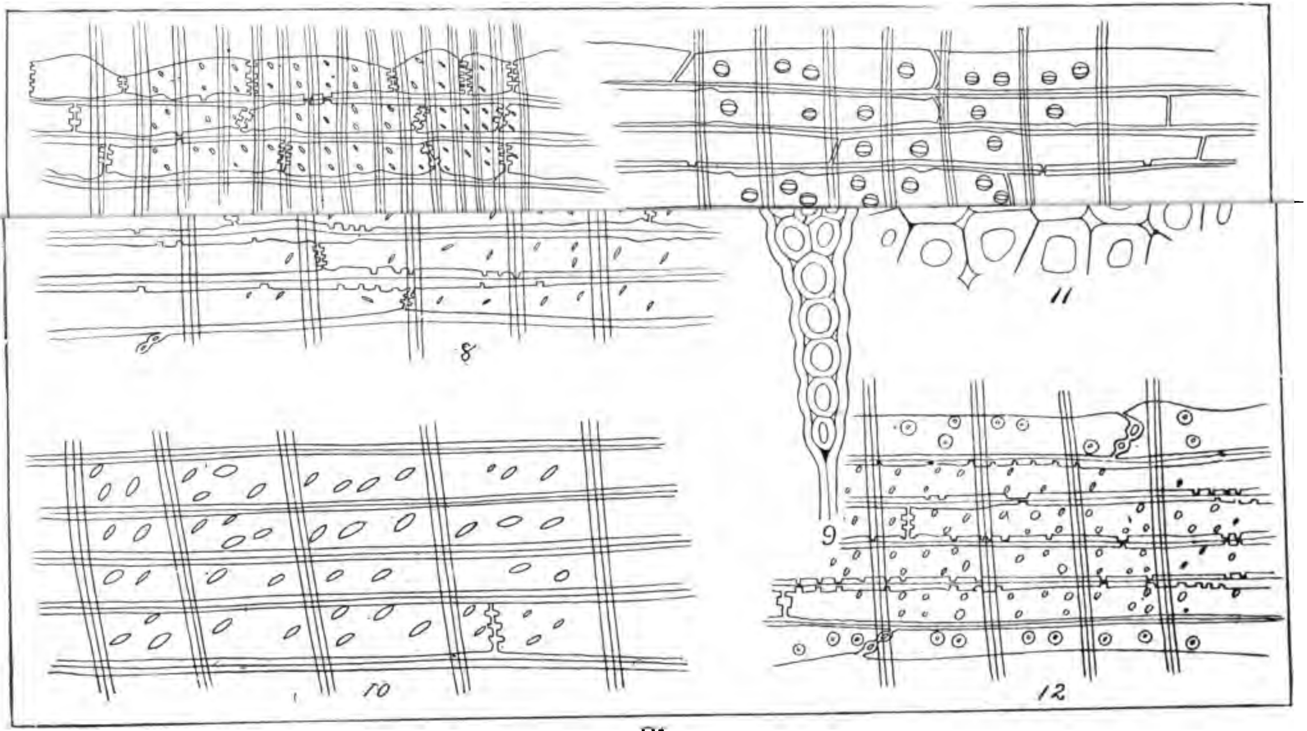
PLATE VI.

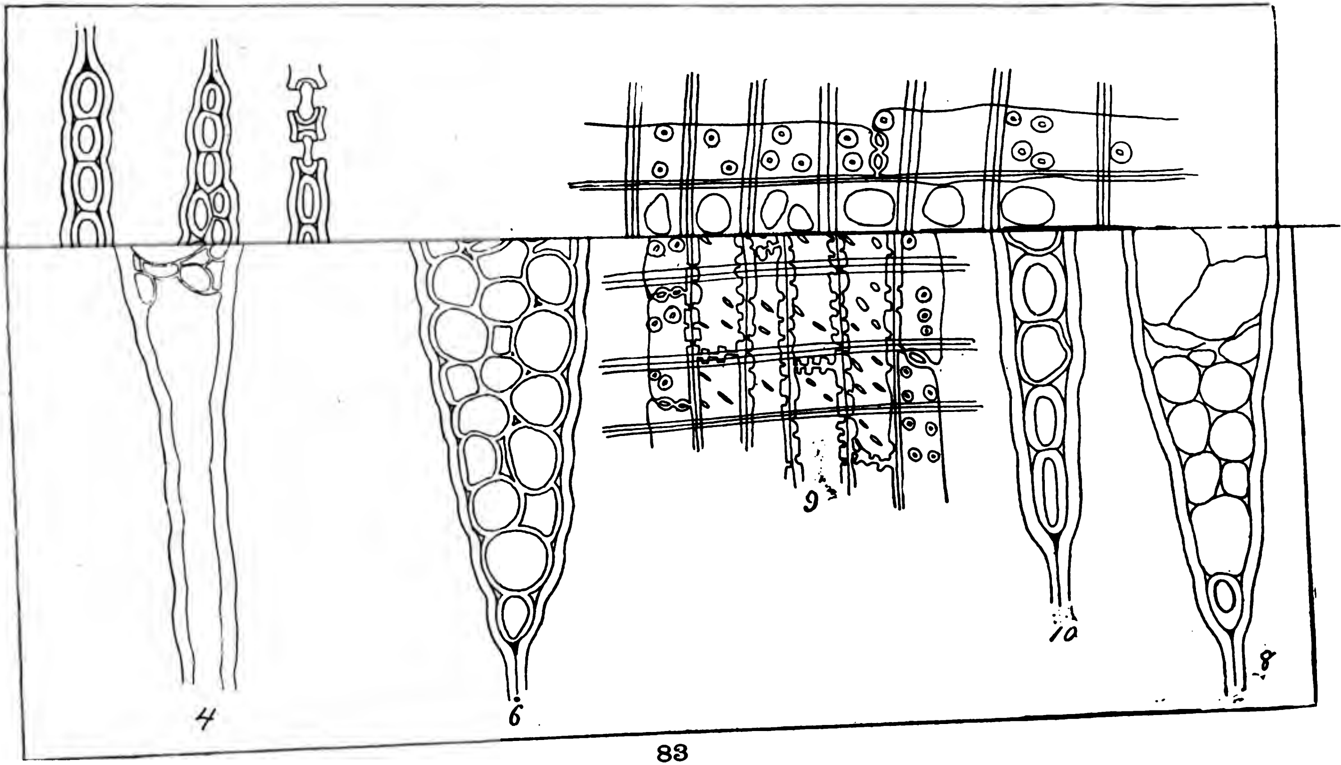
Fig. 1.—*Taxodium distichum.* Transverse section, showing the large tracheids, the double summer wood and the very prominent resin-cells forming a tangential band through the inner zone of the summer wood. × 55.

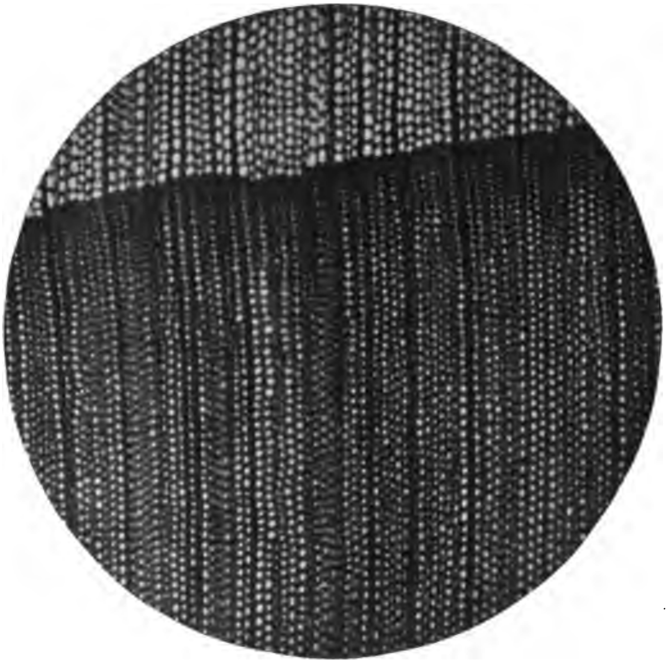
Fig. 2.—*Sequoia sempervirens.* Transverse section, showing the large, squarish tracheids, the prominent resin-cells scattering through the spring wood, and a somewhat compact row of poorly formed resin-passages along the outer face of the summer wood. × 55.

[PENHALLOW] TAXACEÆ AND CONIFERÆ. TRANS. 1896.} SEC. IV. PLATE I.

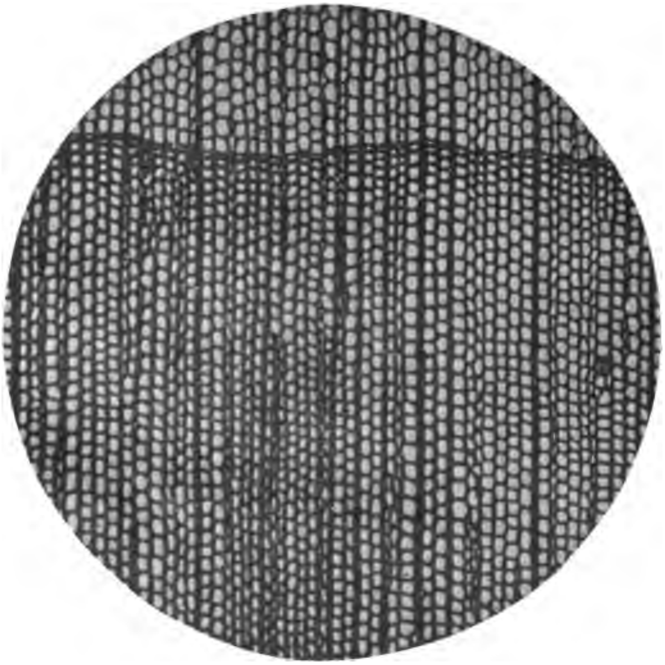




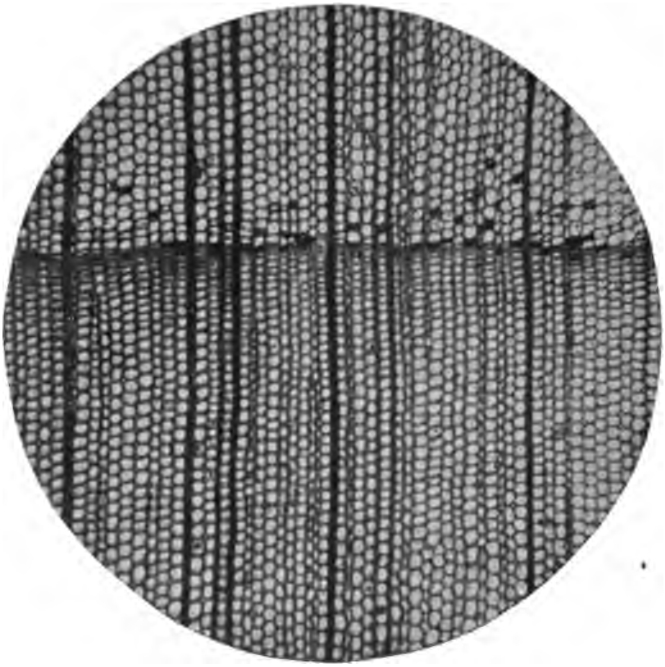




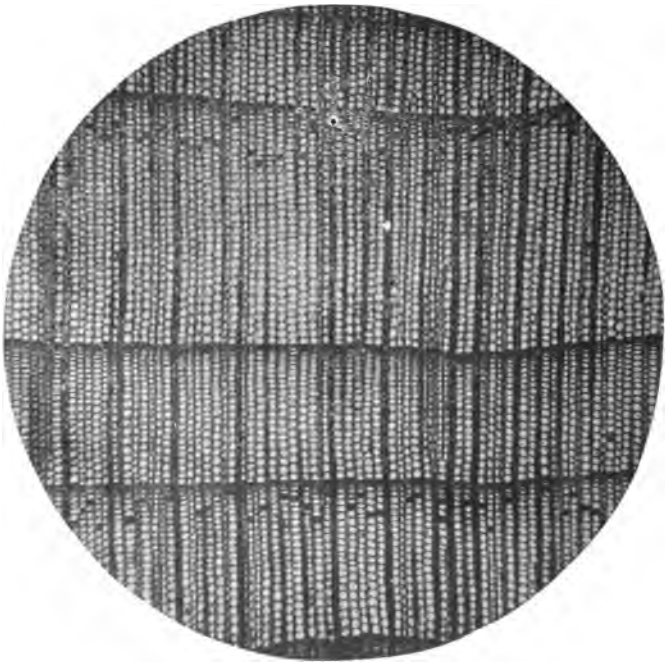
1



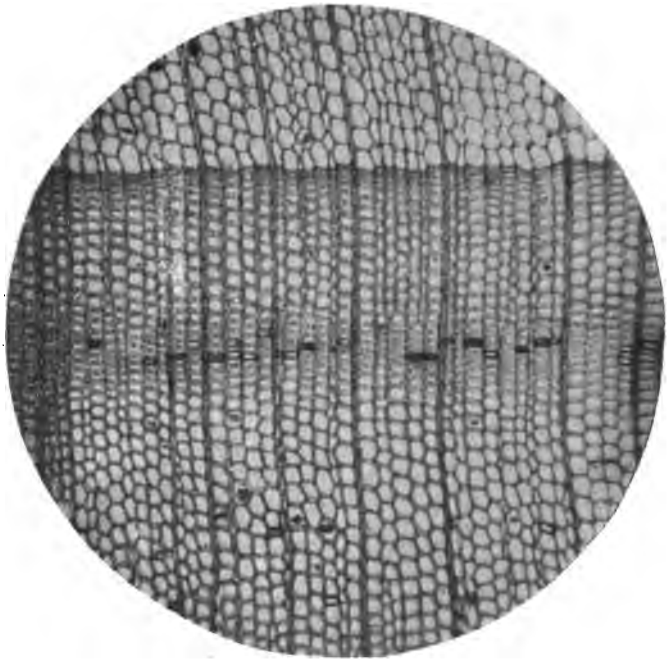
2



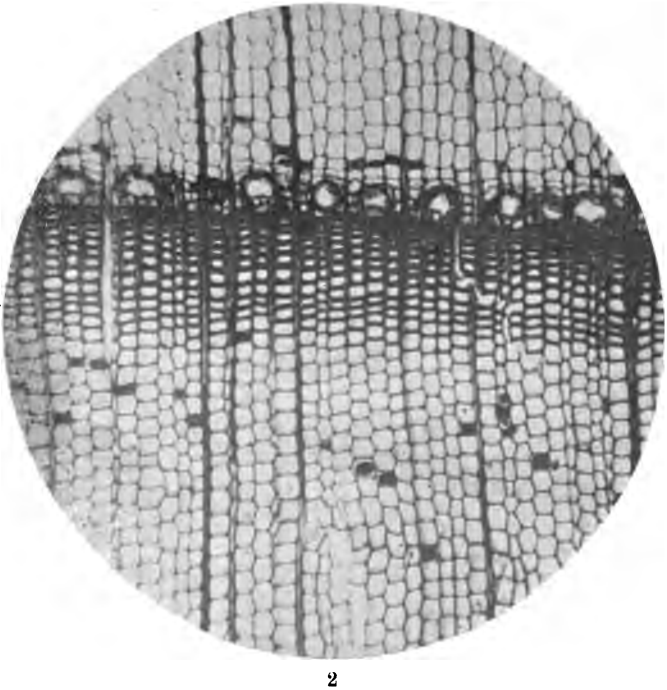
1



2



1



2

3 2044 102 808 912